Microchemistry and magnesium isotope composition of the Purang ophiolitic chromitites (SW Tibet): New genetic inferences

FAHUI XIONG1,2,*, BASEM ZOHEIR3,4,†, PAUL T. ROBINSON1, RICHARD WIRTH5, XIANGZHEN XU1,2, TIAN QIU1,2, AND YI SUN6

1Center for Advanced Research on the Mantle (CARMA), Key Laboratory of Deep-Earth Dynamics of Ministry of Land and Resources, Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China
2School of Geosciences and Resources, China University of Geoscience (Beijing), Beijing 100083, China
3Southern Marine Science and Engineering Guangdong Laboratory, Guangzhou, 511458, China
4Department of Geology, Faculty of Science, Benha University, 13518 Benha, Egypt
5Institute of Geosciences, University of Kiel, Ludewig-Meyn Str. 10, 24118 Kiel, Germany
6Helmholtz Centre Potsdam, GFZ (German Research Centre for Geosciences), 14473 Potsdam, Germany

Keywords: Purang opholite, SW Tibet, UHP-SuR mineral inclusions, high-Cr and high-Al chromitites, deep mantle recycling, SSZ processes

Abstract

New petrographic and microanalytical studies of mineral inclusions in the Purang ophiolitic chromitites (SW Tibet) are used to scrutinize the evolution of the associated Cretaceous sub-oceanic lithospheric mantle section. Silicate inclusions in the chromite grains include composite and single-phase orthopyroxene, clinopyroxene, amphibole, and uvarovite. Most inclusions are sub-rounded or globular, whereas a few inclusions exhibit cubic/octahedral crystal morphologies. The latter are randomly distributed in the large chromite grains, though discrete aggregates are consistently confined to the grain centers. Abundant micrometer-scale, clinopyroxene inclusions are toptaxially aligned along crystallographic planes. Less-abundant sulfide, wüstite, apatite, and uvarovite inclusions are observed in some samples.

The trace element geochemistry of the Purang chromitite evoke parental MORB- and boninite-like melts, consistent with the supra-subduction zone setting. The δ26Mg values of the high-Cr and high-Al chromitites range from –0.25 to –0.37‰ and –0.05 to –0.32‰, respectively. The associated harzburgite has nearly overlapping δ26Mg values of –0.13 to –0.37‰, but pyroxenite sills show distinct δ26Mg values (–0.61 to –0.67‰). The variable Mg isotope signatures, combined with abundant exotic, ultra-high-pressure and super reduced (UHP-SuR) mineral inclusions in the chromite grains, suggest that recycling and recrystallization under different mantle conditions played an important role in the genesis and evolution of these rocks. Furthermore, discrete silicate, sulfide, and metal alloy inclusions in the Purang chromitites are comparable to those reported in other Tethyan ophiolites, and collectively suggest a common geodynamic evolution.

Introduction

The occurrence of ultrahigh-pressure (UHP) minerals, such as diamond, coesite, and lamellar exsolutions of clinopyroxene in chromitites from many ophiolitic belts has raised several questions about processes operating in the formation of the oceanic lithosphere (e.g., Yang et al. 2007, 2014; McGowan et al. 2015; Satsukawa et al. 2015; Su et al. 2015; Gong et al. 2016; Xiong et al. 2018; 2019; 2020a). Micro-diamonds occur as inclusions in ophiolitic chromitites, with morphologies and carbon isotopic signatures dissimilar to diamonds in kimberlites and high-grade metamorphic rocks (e.g., Liou and Tsujimori 2013; Griffin et al. 2016). Unlike diamonds in other geological matrices and environments, the ophiolite-hosted micro-diamonds (and moissanite) are commonly surrounded by amorphous carbon (a hard solid glass, occasionally contains small chromite grains; Yang et al. 2014).

The paragenetic relationships of most ultrahigh-pressure and super-reduced (UHP-SuR) mineral phases in ophiolites are largely unidentified. Results of numerous experimental investigations indicate that the formation of diamonds and other UHP-SuR minerals in ophiolites occurs at depths between 150 and 300 km (Yang et al. 2007; Yamamoto et al. 2009; Xiong et al. 2015). Also, peridotites with SuR-UHP mineral inclusions could have been transported to the lithospheric mantle by passive upwelling (forced return flow), likely induced by downward penetration and roll-back of a subducting lithospheric slab (e.g., Arai 2013; McGowan et al. 2015; Griffin et al. 2016), or related to a super-plume event (e.g., Maruyama et al. 2007; Liou and Tsujimori 2013; Xiong et al. 2015).

Magnesium isotopes have unique systematics in mantle and crustal materials, offering a new approach for tracing crustal vs. mantle source components in the arc magmas. Most significant Mg isotope fractionation is related to low-temperature geological processes, whereas little fractionation occurs at high temperatures and pressures (Teng et al. 2007, 2010a, 2010b).